

Challenges to Transferring and Sharing of Tacit Knowledge within a Construction Supply Chain

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Abstract

Purpose – This paper investigates the potential challenges that hinder the effective transfer and sharing of Tacit Knowledge (Knowledge Communication) within a construction supply chain (CSC).

Design/Methodology/Approach – This study identifies six challenges (through literature review) with fifteen positive correlations between them. Quantitative methodology is employed to validate those challenges and correlations between challenges. Firstly, data is collected through semi-structured e-survey questionnaire. Afterwards, a Frequency and Kruskal-Wallis H test is run for initial validation of identified challenges. A correlation analysis is used to highlight the taxonomic relations between those challenges. Finally, the study establishes the rank order of the first and following challenges.

Findings – This study highlights that traditional ways of working with construction organisations are the predominant challenge that hinders effective transferring and sharing of Tacit Knowledge. The cause of challenges is the fragmented nature of CSC. Also, it brings out the correlation between those challenges. The study draws the conclusion and recommendation to implement Knowledge Communication (KC) within a CSC.

Originality/Value – The study highlights the challenges that hinder KC in a construction process of a CSC. It establishes that the fragmented nature of the construction sector is not the first challenge that hinders implementation of transferring and sharing of Tacit Knowledge but somewhat traditional organisation structures and working processes. This is the first paper that investigates and tests the challenges in four dimensions and establishes the rank order of challenges with crucial distinction in a KC approach within a CSC.

Conclusion – This study identifies the rank order of challenges. It also discusses the implementation of KC within a CSC. It reflects the current understanding of KC in the construction sector and pinpoints the contribution of this study in academia and practice.

Keywords - Construction Supply Chains, Knowledge Management, Tacit Knowledge, Transferring and Sharing Tacit Knowledge, Knowledge Communication in Construction Processes, Knowledge Communication

Introduction

A typical CSC includes hundreds of agents such as Project Managers, Main Contractors, Architects, Quantity Surveyors, Structural Engineers, M & E Engineers, Sub-Contractors, Component manufacturers. Construction projects typically involve tens to hundreds of companies, supplying materials, components, and a wide range of construction services (Cheng et al., 2010). Resultant, the construction industry remains characterised by the adversarial practices and dis-joint supply chain (SC) relationships (Briscoe & Dainty, 2005). To deliver value to the client, the construction industry needs integration of construction processes and products (Egan, 1998). Resultant, bringing collaboration among organisations within a CSC has always been a challenge. The CSC perspective has heightened visibility of this challenge.

Background

To bring collaboration to a CSC, many solutions such as adopting lean, agile, knowledge management have been suggested. However, attempts to implement lean, agile and knowledge management have failed to bring collaboration to a CSC. There are two reasons

for failure: (1) existing studies have investigated these concepts as separate and distinct functions (2) the common challenges that hinder the implementation of knowledge management (KM) in a CSC are often ignored. Therefore, this study focuses on the challenges that hinder KC in a construction process within a CSC.

Knowledge Management

The phrase "Knowledge Management" provides a technological base for managing knowledge. An association of companies in the USA started the Initiative for Managing Knowledge Assets in 1989. KM-related articles began appearing in journals like Sloan Management Review, Organisational Science, Harvard Business Review, and others. The first books on organisational learning and KM, for example, Senge's "The Fifth Discipline." were published then. However, the roots of KM have traced back to the late 60's and the early 70's in Anglo American literature by Zend, (1969) in his article "Management of the Knowledge Organisations". In simple terms, KM is the capturing, coding and sharing the information within the organisations or between a set of multi-organisations. Although, there is no single accepted definition, Devenport, (1994), has given the most cited definition of KM. It defines "KM is the process of capturing, distributing, and effectively using knowledge."

Intuitively, "KM is a process or practice of creating, acquiring, capturing, sharing and using knowledge, wherever it resides, to enhance learning and performance" (Scarborough et al., 1999). KM is vital for efficiency in project delivery and improving organisational competitiveness. KM also promotes innovation and business entrepreneurship, helps in handling change, and empowers employees (Egbu et al., 2005). Saini (2015) defines KM as, "process of identifying, transfer and effectively sharing knowledge to support other processes, wherever and whenever required."

Koenig (2012) observed that the consultant community offered the KM as a product after gaining the expertise on the Internet. Similarly, Nonaka and Takuchi (1995) contended that knowledge resources are the only assets of an organisation. Furthermore, Koeing, (2012) argued that KM is needed to make information and data available to the stakeholders through portals and with the use of content management systems. Content Management, sometimes known as 'Enterprise Content Management', is the most direct and prominent part of KM. Nevertheless, Stewart (1997) added, "Knowledge has become the primary ingredient of what we make, do, buy and sell. As a result, managing it, finding and growing intellectual capital, storing it, selling it and sharing it; become the most important economic task of individuals, business and nations." Fink & Disterer, (2005) argued that the most valuable knowledge is believed to be closely tied to the person who developed it, is mainly transferred by direct person-to-person contact; the approach is therefore called a "personalisation" approach (Hansen et al., 1999). That form of knowledge is called Tacit Knowledge.

Tacit Knowledge

In the KM domain, scholars have several distinct views about the Tacit Knowledge. Egbu et al. (2005) stated, "Tacit Knowledge is deeply implicit in everyone's actions and experiences and the ideals, values, and emotions that they embrace or exhibit." Later, Patgirage et al., (2013) defined, "Tacit Knowledge is understanding, capabilities, skills and the experiences of individuals; often expressed in human actions in the form of thoughts, points of view, evaluation and advice; generated and acquired through past experiences, individuals, and repositories; utilised for the benefit of individual and organisational development." Afterwards, Saini (2015) highlighted, "The Tacit Knowledge is an embedded series of folded

thoughts and point of views in a human's mind, which are gained over the time by experience, learning, sensing, analysing, witnessing and observing a process or series of processes within the physical world.”

Western philosophers have generally agreed that knowledge is ‘justified true belief’. Plato (1968) said, knowledge could only be obtained by the physical world, which can be sensed by the eyes, ears and from the whole body. On the other side, Aristotle criticised sensory perception always occasions the knowledge of forms. The two forms of knowledge creation, explicit and Tacit Knowledge has the critical dynamics of knowledge creation. An individual is a principal-agent who possesses and process knowledge. There are three levels of knowledge creation, the individuals, the group and the organisational knowledge. Business knowledge generally is of two types:

First, Explicit Knowledge is codified, and can be defined, reduced to writing and shared and protected by the legal system. Explicit knowledge is tangible, can be seen and sensed by the touch, and is readily available to use.

Second, Tacit Knowledge expressly knows how, and is by nature difficult to describe. It can be demonstrated but rarely codified, and resides with its holder. It is transferred through demonstration and on-the-job training. It is the form of knowledge, which stays in the mind of individuals could be hard to capture or articulate in words or explanation, mainly it is related to complicated knowledge such as art, which cannot be specified in details and cannot be transferred by perception (Polanyi 2009).

The distinction between explicit and Tacit Knowledge is important because each must be managed differently. The use of technology in construction has eased the management and communication of explicit knowledge. However, communicating Tacit Knowledge is still a challenge that is faced by the construction sector. That is because of the nature of the Tacit Knowledge that remains in the mind of individuals and relies on them to share or carried away. Egbu et al., (2005); Suresh and Egbu, (2006), stated that more than 99 per cent of construction knowledge stays within the mind of individuals and is carried away once the project is finished. That type of knowledge is related to the construction innovation, process improvement and quality improvement. Construction knowledge also involves the knowledge of decision making, delay management and mitigating risks during the construction phase.

Knowledge Communication

Knowledge communication is a way to share and transfer knowledge. Poor and inconsistent communication in a construction project is a critical issue (BIS, 2011) because it results in poor planning and poor design. There are several studies worldwide (Odeh and Battaineh, 2001; Toor and Ogunlana, 2008; Sweis et al., 2008; Nasrun et al., 2014; Ramanathan et al., 2012), 2009) that evidence that the poor management of communication is the main cause of delay in construction projects. However, as discussed above, the main concern of capturing the construction knowledge and communicating (sharing and transferring) it. To bring innovation in construction that knowledge needs to be captured and communicated.

Knowledge Communication in Construction

In (2004) the report “Partnering in Practice” by (Brewer & Johnson, 2004) Price Waterhouse Coopers and HM Treasury Standardisation of PFI Contracts Version (3) suggested, the CSC should be structured in a way to enhance Public-Private partnering. The report contended that there is a real need to define and communicate better to enhance partnering and collaborative

working. It also emphasised that collaborating allows the public sector to combine its skills and resources with those of the private sector. The report concluded with the three types of potential partner grouping in a CSC (a) Bilateral partnering (Applies to the client and main contractor), (b) Multi-party partnering (Applies between the client, main contractor and key sub-contractors) and (c) SC Collaboration (SCC) (This applies to all the parties such as primary contractors, sub-contractors and sub-sub-contractors) excluding client.

In a pragmatic study, The Wolstenholme Review (2008), 'Never Waste a Good Crisis' concluded that the construction industry had made a little progress toward Latham (1993, 1994) and Egan (1998 and 2002) targets. Also, in a recent report by (Magdalena et al., 2013) highlighted that the construction industry becomes more adversarial and less integrated as a result of the current downturn.

The BIS (2013c) report suggests that construction SMEs' growth has fallen since 2010, mainly business capabilities have seen the worst fall, and the processes have not seen any improvement in the last five years. Based on the facts of 1990's recession, Baldauf and Hubbard (2011) showed concern and suggested, *"The construction skills on all levels and of all disciplines were lost in previous recessions, with large numbers not returning, often through choice. In particular, it has been suggested that the industry not truly recover its skills base from the recession of the 90s."* The BIS (2013c) report also highlights skill loss in construction companies is because SMEs are seeking advice and information in the wrong place.. The other report by (Magdalena et al., 2013) highlights that the primary driver for long-term growth is increasing organisational capabilities to export. However, the factors and areas of concern in increasing exports are (1) People and Skills' enhancement, (2) Innovation Capabilities and (3) SC development.

In a CSC development, Taylor, (2012) and Alashwal et al., (2011) conceived main problems such as the fragmented SC, the lack of SC integration and collaboration and insufficient KM systems are either dependent or related to each other. It is also observed that the fragmented nature of the CSC is due to (a) the lack of process integration and (b) lack of collaboration (Alashwal et al., 2011 and Ribeiro and Fernandes 2010). However, Taylor (2012) and Alashwal et al., (2011) argued that lack of process integration, partnering, collaboration in CSC is the causes of insufficient KM systems. The literature of CSCs suggests that the existing KM systems fail to transfer and share (Communication) Tacit Knowledge (Saini, 2015). Therefore, there is a significant need to identify and investigate the challenges that hinder the implementation of KC in a CSC.

The existing literature argues that KM and skills are required in the construction companies to enable them to integrate efficiently within a CSC (Kivrak & Arslan, 2008). Furthermore, (Alashwal et al., 2011) suggested, in reducing the negative impact of fragmentation by developing collaboration in a CSC through KC (transferring and sharing Tacit Knowledge). The core problems in CSCs are wasteful KM systems. Moreover, inefficient KM system enhances lack of trust and commitment among the stakeholders. Lack of trust leads to inactive collaboration, entrusted partnering and inefficient process integration in CSCs. Nevertheless, lack of collaboration and integration is considered as the negative impact of fragmentation in CSCs due to the lack of skills of KC.

The identified challenges and interrelationship between problem and leading cause and supporting factors is populated in below table (1). Each section in this table is to spotlight the challenges, which hinders KC in CSCs.

In section (1) of the table (1), a fragmented SC is the main problem. The main causes that lead to fragmentation are (1-A) lack of collaboration and (1-B) lack of process integration in a CSC. The supporting factors of fragmentation in a CSC are a large number of small and medium companies. The section (2) represents that the fragmentation in CSCs is due to the lack of active KM systems that is supported by (2-A) lack of trust and commitment and (2-B) lack of motivation. Moreover, the reason why a KM system fails is due to the insufficiency of communicating Tacit Knowledge. In section (3), the reason for insufficient KC is (3-A) lack of KC capabilities and (3-B) lack of awareness of the importance of KC.

Table 1: Inter-relation of main, sub-causes and its supporting factors/challenges

Problems	Causes	Supporting factors/challenges
Section (1) Fragmented Supply Chains	1-A: Lack of Collaboration	<ul style="list-style-type: none"> •A large number of small and medium companies •Lack of skill and knowledge of collaboration and partnering •Lack of Motivation •Lack of trust and commitment •Short project lifecycle
	1-B: Lack of Process Integration	
Section (2) Lack of Effective Knowledge Management Systems	2-A: Lack of Trust and Commitment	<ul style="list-style-type: none"> •Lack of support available to small and medium firms •Lack of awareness in seeking support •Lack of learning capabilities •Lack of decision making knowledge •Short project lifecycle
	2-B: Lack of Motivation	<ul style="list-style-type: none"> •Lack of human resource capabilities •Lack of organisational strategies •Lack of reward system
Section (3) Inefficiency in transferring and sharing Tacit Knowledge	3-A: Lack of Knowledge Transferring and Sharing capabilities	<ul style="list-style-type: none"> •Lack of organisational capabilities •Lack of learning capabilities •Lack of awareness of gaining competitive advantage through KM •Lack of financial resources •Lack of awareness in seeking support •Lack of awareness of Knowledge Management
	3-B: Lack of awareness of knowledge transferring and sharing	

Source: Based on literature from Carroll, & Burton, (2012); Alashwal et al., (2011); Khalfan & McDermott, (2007); London & Kenley, (2001)

This study highlights, fragmentation in the construction sector is due to several causes. The critical analysis of literature leads this study to the causes such as lack of collaboration and lack of process integration within CSC. These causes are preserving the negative impact of fragmentation. Further, the study highlights that collaboration within CSCs is because of the lack of KM systems. Which further supports lack of trust among organisations and lack of motivation among organisations and individuals. We identify six main challenges that create obstacles which hinder KC in the CSCs. The next section identifies and explains the challenges to be considered in this study.

Challenges to Achieving Knowledge Communication

Fragmented nature of the construction sector

A fragmented SC is the first challenge. The leading causes of fragmentation are (a) lack of collaboration and (b) lack of process integration in a CSC. The supporting factors of fragmentation in a CSC are about 99 per cent of small and medium enterprises (ONS, 2014). This problem intensifies by the fact that a CSC typically involves several specialised disciplines (Caballero et al., 2012). Having those disciplines originate from sub-letting firms for a construction project. The study by Wu (2009) concluded that the sub-letting practice in construction is often more profitable for construction firms. Having said that the fragmentation in the construction industry is for a purpose that enables small firms to contribute and survive in the sector. However, fragmentation of design, fabrication and construction functions leads to cost, time and quality-related issues. These issues later develop additional liability claims and other issues such as lack of integration, collaboration and coordination between various functions and leads to poor communication.

Lack of understanding and importance of KC

Successful integration of an SC requires timely information exchange and communication throughout the supply chain (Konukcu, 2011). The KC is an essential factor for temporary organisations that need the ability to integrate individual knowledge (Lindner & Wald, 2011). However, lack of importance and awareness of KC in short-term SC's, temporary organisations face particular obstacles. BIS (2013b), a small business survey reveals that the organisations are not aware of the right sources to seek knowledge.

Lack of trust among the organisations in CSCs

Trust in construction was perceived to assist leadership, team building, communication and information sharing (Zuppa et al. 2016). However, lack of trust is among the primary sources of concern among the workers who create knowledge about operations in construction (Arif et al., 2015). A competent KM system can fall back if the trust and commitment of the individuals and organisations are missing. Lack of trust leads to inactive collaboration, entrusted partnering and inefficient process integration in CSCs. Trust is something whereas institutional relations allow for the development of confidence (Weber & Carter, 1998). However, building trust in a CSC is a predominant challenge. Ceric (2012) concluded that trust is the most crucial risk-minimisation strategy in a construction phase.

Insufficiency of motivation for organisations in CSCs

The literature suggests that there is an insufficiency of motivation among construction organisations to initiate KC. Therefore, BIS (2013b) suggests, the process improvement remains constant in the construction sector. However, the UK construction SMEs precepts

that in 2012 only 64% of companies aim to grow in the next two to three years, compare to 78% companies aimed in 2010. BIS (2013b) conclude “Aim to Growth” requires motivation for intellectual capital growth, and it has seen a 14% downfall since 2010. Moreover, there is a lack of motivation to drive trust and transfer and sharing of knowledge. However, that requires the involvement of the client to establish business strategies that drive trust by introducing incentives and motivation (Saini, 2015).

Short-term SC relationship among partners of CSCs

A short-term SC perspective and collaboration make it harder to develop new knowledge in the CSCs. Short-term CSCs are often not integrated (Khalfan & McDermott, 2007). The short-term relationship encourages an adverse relationship that prevents trust and collaboration. Mansfield and Odeh (1991) concluded that short-term relationship is an issue that lessens motivation on construction projects.

Contractors have a traditional way of doing business

Recent research of BIS (2014) revealed the barriers and strategic challenges for construction UK SMEs. The research highlights the total population of UK construction SMEs in 2012 were 907,195. Furthermore, the UK construction sector included 72% family-run businesses in 2012. As discussed earlier, there is 17% downfall in the improvement of new products and services (Lomax et al., 2013). Moreover, a negative awareness to improvement in skills of workforce and increase of exploiting skills is recorded. Nasrun et al., (2014) said that the traditional ways of working in construction generated many problems associated with fragmentation in CSCs. The traditional practice also hinders the integration of construction knowledge that diminishes the opportunity to influence decisions.

Methodology

The study aims to investigate the obstacles in a CSC. This investigation adopts a systematic research methodology to define the challenges through literature review. The “Knowledge Driven Research Methodology Model” originated by Saini (2015) has been adopted to drive the research. Based on the literature review, this study lays down six challenges. This study adopts a systematic research methodology to investigate those six challenges through quantitative methods. Based on each challenge, a hypothesis is established (see below table 2).

Table 2: Methodology Adopted

Main Question	What is the level of criticality of the below listed challenges associated with the KC within a CSC?				
Main Hypothesis	The level of challenge associated with the KC within a CSC is a highly critical challenge.				
Likert Scale	Not Challenging	Of Little Challenging	Moderately Challenging	Challenging	Highly Challenging
Ranking	1	2	3	4	5
Data Type	Ordinal				
Data Analysis Technique/s	Reliability, Frequencies, Correlation and Non- parametric Analysis and Rank Order Analysis				
Challenge	Hypothesis				
V1	Lack of understanding and importance of implementing KC within a CSC is highly challenging				
V2	Lack of trust is highly challenging factor that hinder implementing KC within a CSC				
V3	Insufficiency of motivation is highly challenging factor that hinder implementing KC within a CSC				
V4	Short-term supply chain relationship among partners is highly challenging factor that hinder implementing KC within a CSC				
V5	Traditional ways of doing business is highly challenging factor that hinder implementing KC within a CSC				
V6	Fragmented nature of the construction sector is highly challenging factor that hinder implementing KC within a CSC				

To test the hypothesis (in table 2 above), a questionnaire was designed with a five-point Likert scale to capture the views of respondents. The data is categorised as ordinal scale and analysed in SPSS with Frequency and Kruskal-Wallis H test. Also, Spearman's correlation analysis is used to investigate the preceding and following factors. Finally, an interpretive rank order analysis is employed to establish the relative importance of those factors.

Reliability of data requires consistency. Reliability can be assessed by considering three main points, (1) will it measure yield the same result on other occasions? (2) Will the similar observations be reached by other observations? Moreover, (3) will the raw data produce the transparency in a sense, as observed by Easterby-Smith et al., (2008) Cronbach's alpha is employed to measure the internal consistency (a measure of reliability) for this study. It is used to determine the items within a scale measure the same underlying dimension (Bland & Altman, 1997). It measures reliability with multiple Likert's scale questions (Yu 2001). Since the questionnaire employs a Likert scale, it gives ordinal data that demands non-parametric data analysis (Ghasemi & Zahediasl, 2012).

Sampling boundaries are required. The approach below was adopted to choose the target respondents. A typical CSC can be described in three tiers. In this study, the main contractors with a first-hand commercial relationship with the client are termed Tier 1. Sub-contractors with a direct contract with the (Tier 1) main contractor are termed Tier 2. Sub-contractors and suppliers working for sub-contractors are termed Tier 3. The (Tier 3) sub-contractors also employ suppliers and sub-contractors. Therefore, in many cases, there will be a fourth or even fifth Tier participating in construction delivery. However, this study is limited to the Tier (2) level and above because of the facts below.

1. This study is restricted to respondents who hold the knowledge and understanding of KM, construction processes and CSCs. Also, the respondents must be directly involved in the KM, and SC Processes, which falls within and below Tier (2) of CSC.
2. In construction, SC members beyond Tier (2) are not usually involved in implementing KC within a CSC. Beyond Tier (2) the manufacturers and suppliers are direct SC of sub-contractors and may not ever be involved as direct stakeholders in a construction project.
3. Only the Project Managers, Main Contractors and the Sub-contractors, are the organisations and individuals who have direct involvement in the planning and execution of the construction process (BIS 2013).
4. Due to the fragmented nature of construction industry and lack of skills and knowledge of disciplines mentioned above in Tier (3) contractors, manufacturers and raw material suppliers also restrict this study to employ respondents' in the SC level named Tier (2).

Resultant, this study recruited respondents such as Project Managers, executives, consultants, and other managers who are directly involved in the management of a construction project.

This study explored different data sources to understand and establish the sample size. Due to relatively limited resources available to researchers, obtaining large sample sizes from the construction industry is challenging. Hannan & Anderson (2007) reveals that most type of statistical analysis requires a minimum 30 responses. However, some statistical analyses need more than 100 responses. Through a statistical analysis, Saini et al., (2017) observed an average 25.75% survey response rate from the UK construction industry. That means, for minimum 30 responses the target population is at least 120, and for a maximum of 100 responses the target population is 400.

An anonymous e-survey questionnaire is administrated, and the link is published on relevant websites that represents community-of-practice groups in SC, KM and KC in construction. Also, about 250 emails were sent to the top hundred construction companies in the UK. Eighty-three (83) responses were received, which were relevant to conduct the aforementioned statistical analysis. Since a link to e-survey was sent through different portals including emails; it is not viable to calculate the response rate.

The questionnaire was designed with five (5) point Likert scale to capture the views of respondents. The questionnaire design through a Likert scale produces data in an ordinal scale (non-parametric). Having, the ordinal scale of data provided the opportunity to analyse in SPSS while running Frequency analysis (to understand the mean, median and mode statistics), Kruskal-Wallis H test to test the hypothesis and identify the asymptotic significance of data (against Mann-Witney- because of more than two variables). Also, Spearman's Correlation analysis to establish the correlation between the challenges (against Pearson's Correlation analysis- because of not normally distributed data). The hypothesis for each challenge was set to 'highly critical' to test the hypothesis through, Mean, Median (Frequency, and Kruskal-Wallis H test) and Asymptotic Significance (Kruskal-Wallis H test). That provided the opportunity to test the data in four dimensions (including literature review), and finally, an interpretive rank order analysis is performed to establish the essentiality of those challenges based on the rank order.

Eighty-three (83) responses were received. The number of responses gave the research team confidence in the data and indicated that valid inferences could be drawn from this data. A high level of internal consistency for this data is calculated, as Cronbach's alpha (α) is 0.702. The respondent's experience is the basis for their response.

Data Analysis

Hypothesis Testing

The Frequency analysis in table 3, the highest (44.9%) of respondents said that the lack of understanding and importance of KC (V1) is 'Challenging'. The second highest (34.8%) respondents said 'Moderately Challenging'. Moreover, the mean value for this variable is calculated as 'Challenging' (4.00).

Nevertheless, Table 2 exhibit the median score is (4.00) and Asymptotic Sig. (2-sided test) p -value is 0.890 (above > 0.05). This meets the assumptions that the null hypothesis to be accepted. It also established that the lack of understanding and importance of KC is significantly 'Challenging' factor that hinders the application of KC within a CSC.

Table 2: Descriptive and Kruskal-Wallis Analysis

Descriptive Analysis							Kruskal-Wallis H Test					
No	Frequency	1 Not Challenging	2 Little Challenging	3 Moderately Challenging	4 Challenging	5 Highly Challenging	Mean	Median	Ordinal Rank	Statistically Significantly Distributed	p- value	Status
V1	Frequency	4	2	11	41	11	4	4	Challenging	Yes	0.971	Accept
	Percentage	5.80%	2.90%	15.90%	59.40%	15.90%						
	Cumulative	5.80%	8.70%	24.60%	84.10%	100%						
V2	Frequency	3	1	12	33	20	4	4	Challenging	Yes	0.861	Accept
	Percentage	4.30%	1.40%	17.40%	47.80%	29.00%						
	Cumulative	4.30%	5.80%	23.20%	71.00%	100%						
V3	Frequency	0	4	15	28	22	4	4	Challenging	Yes	0.252	Accept
	Percentage	0.00%	5.80%	21.70%	40.60%	31.90%						
	Cumulative	0.00%	5.80%	27.50%	68.10%	100%						
V4	Frequency	1	7	38	20	3	3	3	Moderately Challenging	Yes	0.280	Accept
	Percentage	1.40%	10.10%	55.10%	29.00%	4.30%						
	Cumulative	1.40%	11.60%	66.70%	95.70%	100%						
V5	Frequency	3	10	27	21	8	3	3	Moderately Challenging	Yes	0.656	Accept
	Percentage	4.30%	14.50%	39.10%	30.40%	11.60%						
	Cumulative	4.30%	18.80%	58.00%	88.40%	100%						
V6	Frequency	2	11	28	20	8	3	3	Moderately Challenging	Yes	0.212	Accept
	Percentage	2.90%	15.90%	40.60%	29.00%	11.60%						
	Cumulative	2.90%	18.80%	59.40%	88.40%	100%						

The lack of trust among the organisations in CSCs in the application of KC within a CSC (V2) establishes that the highest number (49.3%) respondents said 'Challenging' and the second highest (29.0%) respondents said 'Highly Challenging'. Moreover, the mean value for this variable is calculated as 'Moderate' (4.00).

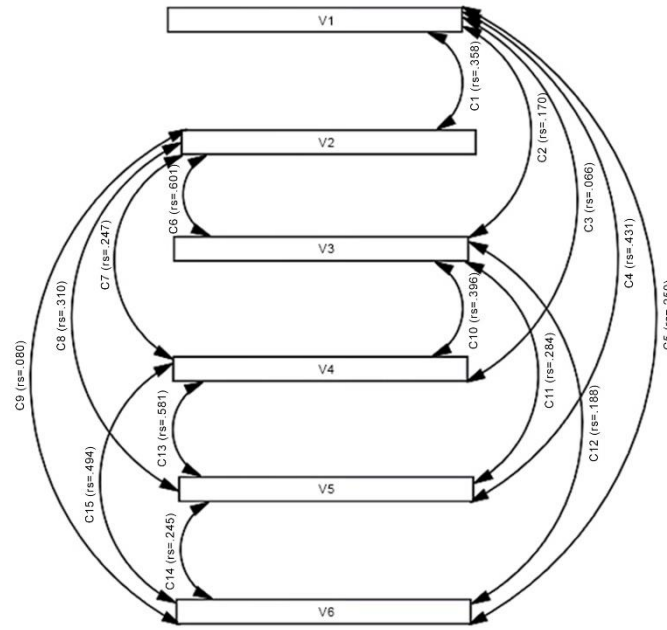
Moreover, the Kruskal-Wallis H test exhibit a median score is (4.00) as assessed by visual inspection. (2-sided Asymptotic Sig.) p -value is observed 0.927 (above > 0.05). Based on the analysis it meets the assumptions that the null hypothesis to be accepted. Which established that the trust between the organisations is significantly 'Challenging' factor that hinders KC within a CSC.

Overall, the median score of 4.00 (Challenging) is calculated for variables (V1, V2 and V3). Moreover, it calculates the mean 3.00 (Moderately Challenging) for variables (V4), (V5) and (V6). The data analysis of this variable (V4) rejects the null hypothesis. The short-term, SC relation is found 'Moderately Challenging' with the Mean value calculated in table 3, as (3.00). The Frequency analysis establishes that the highest number (40.6%) respondents said 'Moderately Challenging' and second highest (37.7%) respondents said 'Challenging'. Moreover, the Kruskal-Wallis H test also establishes that data is not statistically significantly distributed and calculated the Asymptotic Sig. (2-sided test) p -value is 0.046 (below > 0.05) with median value (3.00). However, based on median value and Frequency analysis we could accept the alternate hypothesis that short-term SC is 'Moderately Challenging' in the application of KC within a CSC.

Spearman's Correlation Analysis

Figure 1 below presents the results of fifteen correlation significance between the challenges that hinder the application of KC within a CSC. For presentation purpose, the correlations between challenges are coded as (C1) to (C15).

Based on correlation (C1 to C15) in figure 1 below, the most significant correlation has been found between (V2) and (V3). Between those, the positive correlation coefficient is calculated as ($r_s = .601$). The second highest and positive correlation coefficient ($r_s = .581$) is calculated between (V4) and (V5). The third highest correlation coefficient is found between (V1) and (V5).



Keys:

Variables: V1 to V6

Correlations: C1 to C15

Figure 1: Correlations between Challenges that hinder KC in Application of Lean in a CSC

Rank Order Analysis

Based on correlations the below table 4 exhibits the rank order of correlation coefficients between the challenges from ‘Highest Correlated Coefficient’ (1) to the ‘Lowest Correlated Coefficient’ (5). Ranking these challenges based on correlation coefficient leads this study to final assumptions

In below table 4, in (Rank 1) variable (V5) is highly correlated with (V1, V4 and V6). However, in (Rank 2) Variable (V1) appeared twice and in (Rank 3) Variable (V5) is observed twice. In (Rank 4) and variables V6 and V3 appeared twice. Resultant, Variable (V10) ‘to enhance collaboration among organisations’ in construction processes is highly correlated with (V11) and then (V12) and (V13).

Table 3: Interpretive correlation coefficient rank orders analysis

	Challenges						Frequency (Times)		
	V1	V2	V3	V4	V5	V6			
High	V5	V3	V2	V5	V4	V5	V5 - (3)	1	High
Coorelation ----->	V2	V1	V4	V3	V6	V1	V1 - (2)	2	<---RANK---
	V6	V5	V5	V2	V1	V4	V5 - (2)	3	
	V3	V4	V6	V6	V2	V3	V6 - (2), V3 - (2)	4	
Low	V4	V6	V1	V1	V3	V2	V1 - (2)	5	Low

Assumptions

Based on the interpretive rank order analysis of the correlation between challenges that hinder the application of KC within a CSC the following assumptions based on (Rank 1) is established.

- 1) The most predominant challenge is (V5) the traditional way of doing business, which encourages (V1) lack of understanding and importance of KC and vice versa.
- 2) Contractors' traditional way of doing business is also highly correlated with (V3) insufficiency of motivation and (V6) fragmented nature of the construction sector.
- 3) Due to the fragmented nature of the construction sector and insufficiency of motivation to communicate knowledge, there is a lack of understanding and importance of KC.

Evaluation and Discussion

The central determinations of challenges associated with KC within a CSC are as follows.

Lack of understanding and importance of KC via lack of trust among the organisations and lack of motivation to transfer and share Tacit Knowledge are challenging factors of KC within a CSC. Other challenges, short-term SC relationship, traditional ways of doing business and fragmented nature of the construction sector have appeared 'moderately challenging' factors that hinder the application of KC within a CSC.

In the application KC within a CSC, the predominant challenge observed is the traditional ways of doing business. It also establishes two other challenges namely, fragmented nature of the construction sector and lack of motivation for organisations to transfer and share knowledge.

This also pinpoints that; short-term SC relationship supports the lack of trust between organisations that support the fragmented nature of the construction sector. We learned that understanding of KC and its benefits is limited in CSCs. Due to lack of knowledge, and understanding of KC, the current system such as Building Information Modelling (BIM) is incapable of commitment and motivation to implement KC. Moreover, unclear goals and fuzzy incentives for SMEs discourage their commitment to KC implementation.

It was observed that most organisations are not aware of the tools and techniques for implementing KC. A short-term SC perspective and collaboration make it harder to develop KC in a CSC. Short-term SC's are often not integrated (Khalfan & McDermott, 2007). The short-term relationship encourages an adverse relationship that prevents trust and collaboration. Moreover, the short-term relationship is an issue that lessens motivation on construction projects.

The causes above of fragmentation and supported factors found through literature review match the findings from this statistical study. The literature review suggests that the main challenges are the lack of a KM system. Within KM systems, there is a lack of KC. Moreover, this requires developing awareness to communicate knowledge.

The aforementioned challenge '*traditional ways of doing business*' needs addressing at each level such as Tier 1 (main contractors), Tier 2, Tier 3 and Beyond (sub-contractors) of a CSC. In a CSC Tier 2 and Tier 3 levels represent SMEs, those possess insufficient knowledge and understanding of KC.

The findings from this study match the other recent studies by (Du et al., 2018; Alreshidi, Mourshed and Rezgui, 2017; Liu, van Nederveen and Hertogh, 2017; Chegu Badrinath,

Chang and Hsieh, 2016). These studies also suggest that Adoption of BIM can improve communication within the construction project and between the related parties. Improving communication would help in mitigating delays in construction while improving coordination between construction parties. The other study by Liu, van Nederveen and Hertogh, (2017) taken the grounded theory and focus group interviews approach to analyse the different concepts that influence the communication and collaboration development. The study measured the trust between the parties, individual behaviour, technology and IT capacity. The study concluded that these are the factors that influence the flow of communication within a construction project.

Therefore, the implementation of KC within a CSC remains a myth. The clients and main contractors need to assure that KC is implemented at all SC levels and construction process levels (planning -contracts - bid documents – design – construction – payment – completion). However, implementation of KC requires commitment, motivation, business strategies and leadership that drive KC. This also requires support and training of SMEs. Research has looked into the traditional ways of procurement in construction and identified problems (Khalfan & McDermott 2007). Li et al., (2001), discovers that the procurement routes mainly develop a CSC's structure and different structure produces a different performance. Therefore, it is essential to develop a procurement route that aligns commitment of all organisations in an SC to implement KC.

In a traditional design-bid-build arrangement, an SC mainly consists of two teams Design and Construction (Li et al., 2001). Whereas, the design team consists of architects, engineers, quantity surveyors and other specialists. On the other side, the construction team have main contractors, sub-contractors and suppliers. Figure 2 below exhibits a conceptual model of KC implementation in a CSC.

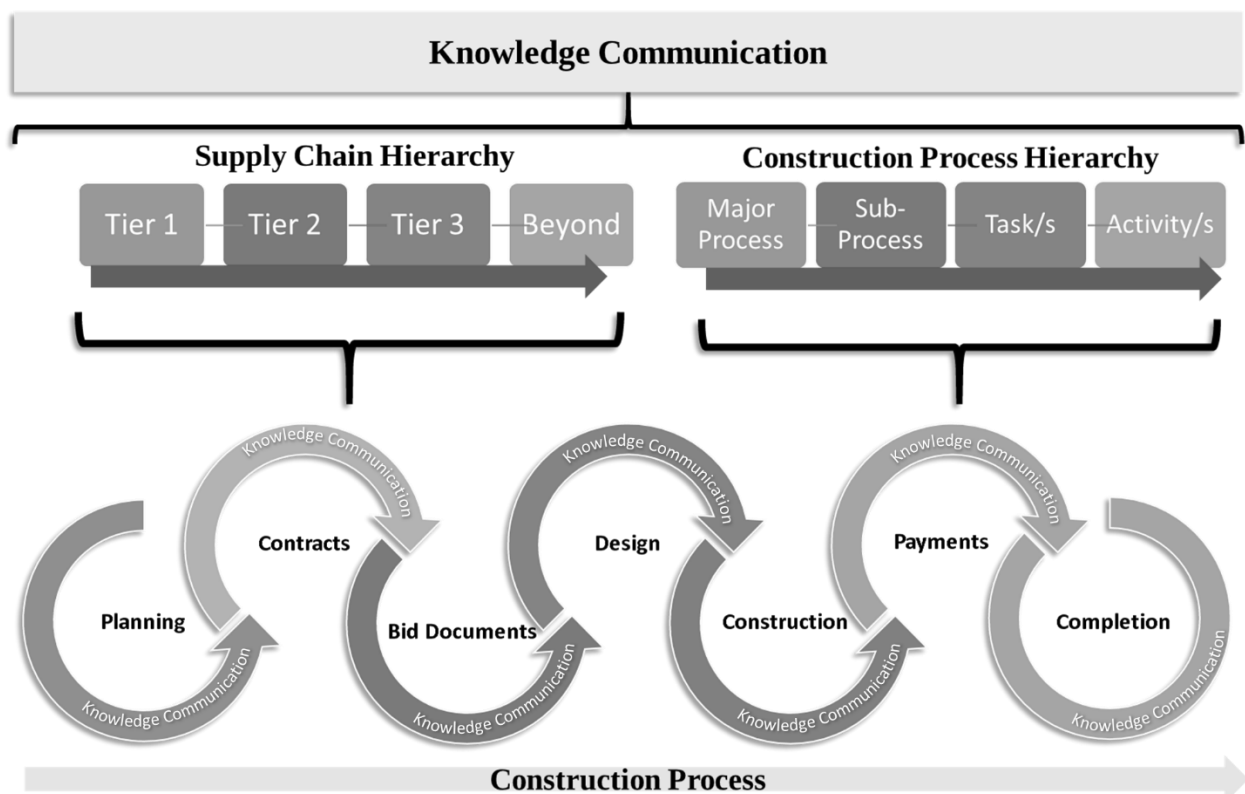


Figure 2: Implementing KC within a CSC and Construction Processes

Practical Implementation of KC within a CSC

We contend that KC needs to be implemented at all levels (SC Hierarchy and Process Hierarchy and construction processes) of a CSC (as shown in figure 2 above). In figure 2 above, the KC is implemented within SC hierarchy and construction process hierarchy; also, it needs to be implemented within all construction phases from procurement until completion phases. However, challenges above need addressing while implementing KC. Mainly, a CSC suffers from traditional ways of working, a collective approach of KC (knowledge sharing and transferring) will help to advance the understanding and knowledge of the benefits of KC in construction SMEs.

As discussed above, the SC hierarchy of a construction project has more than three tiers (Tier 1, Tier 2, Tier 3 and beyond). The issues are the KC between those tiers and those are mainly defined as the main contractor and sub-contractors. Those main and sub-contractors are responsible for the success of the SC of a construction project that involves the construction processes from planning to completion.

In recent research, (Saini et al., 2017), suggested, to implement knowledge transfer and sharing (KC) in the construction process the main contractors and sub-contractors should identify the process improvement opportunities. Afterwards, the source of the knowledge and recipient of the knowledge should include also need identification. However, they also suggested that for KC, trust between the parties, motivation to communicate knowledge, leadership capabilities, aligned business strategies and individual capabilities are essential control variables for KC in a construction process hierarchy and individual activity level.

Therefore, in a construction project management perspective, to implement KC in a construction process such as planning or contract, the main contractors and sub-contractors should identify the process improvement opportunities at the activity level. Once the improvement opportunity is defined, the project scope should be redefined, and the KC should be initiated to innovate and improve the construction process.

Conclusion

The study set out to assess the challenges of transferring and sharing Tacit Knowledge within a CSC. The preliminary study of this paper found that the first challenge of KC within a CSC is the fragmented nature of the construction sector. The emergent theme in the early literature regarding KC within CSCs is ‘the lack of understanding and importance’ is responsible for slow adoption of KC. However, data analysis reveals that the predominant factor is ‘the traditional ways of doing businesses’. There could be many reasons for the primacy of traditional ways of doing business in CSCs. Such as lack of skills in the construction sector (BQF, 2013), lack of adequate support to grow (Brigitta, 2012; Lomax et al., 2013) and lack of learning capacity and capabilities.

The second foremost challenge is the lack of ‘motivation’ to drive KC in a CSC. Lack of motivation is because of the ‘fragmented nature of the construction sector’ and ‘short-term SC relationship’. Different researchers have revealed different findings. Arif et al., (2015) concluded “Trust” as a primary factor of knowledge sharing. The term “trust” has been referred to as the “confidence and faith” between the organisations and the people, that is the heart of knowledge sharing. The third significant challenge is the lack of knowledge about the importance of KC. This study contends that motivation is required to drive trust in a fragmented and short-term SC relationship. The other view is, to advance the knowledge and understanding of the organisations and people involved in a CSC to communicate knowledge.

Driving the KC within a CSC requires awareness of its short-term and long-term benefits for the project, the organisations and its individuals.

Most of the research on the association between KC and CSC finds little evidence of challenges to communicate knowledge in a CSC. The areas where significant differences are found are 'driving trust' for 'KC'. However, there is a strong relationship between 'driving trust within a CSC' and 'traditional ways of working'. Sharing Tacit Knowledge also requires the leaders to convince their employees that they can 'trust' other organisations and colleagues (Arif et al., 2015). However, to convince people to trust others and share knowledge requires training and support to overcome mitigating the traditional ways of dealing with others. Also, (Zhang 2012) indicated that individuals' attitudes toward knowledge sharing are positively affected by knowledge self-efficacy and knowledge feedback, while negatively affected by losing face. Moreover, Wen and Qiang (2016) suggested that coordination behaviours enable knowledge sharing, while knowledge sharing, in turn, does not significantly contribute to the coordination of people.

Reflecting on the main findings posed by the study, this research has made some significant original contributions, particularly in KC domain. The findings of this research are essential that adds knowledge to the application of KC not just within a CSC but also at construction process levels.

This research concludes that the primary challenge is to encourage the construction organisations to communicate with other organisations. However, there is lack of KC frameworks that help to advance the capability of construction organisations to adopt KC practice within the organisation and within a construction project (Saini, 2015; Konukcu, 2011). The model of implementing KC within a CSC and construction process can be generalised to apply in any CSC or a construction process. A generalisation of the model would require collecting data from different construction projects to validate its application. This model can be used as a starting point for further research.

The study also reveals one of the most critical gaps in the literature of construction processes while developing a new literature of challenges in Knowledge sharing and transferring (communicating) and the framework (figure 2) that establish that how KC likely to be implemented.

Some recent studies such as (Arayici et al., 2009; Tessema, 2008; Du et al., 2018; Wang and Love, 2012) contend that use of technology such as Building Information Modelling (BIM) has improved the communication in the construction projects. We do not deny or oppose the capability and efficiency of such technologies. But other recent studies generalise that the poor communication factor supports the ineffective planning and scheduling.

However, the intent of this study is to demonstrate that Tacit Knowledge is out of the scope of such technologies. However, there is a possibility that such technology can be used to capture and coding of Tacit Knowledge once is it shared and transferred to the right knowledge recipient. But the other recent studies such as (Chegu et al., 2016; Davies et al., 2015; Zanni et al., 2013; Du et al., 2018) also contend that even though the matured level of such technologies are not available, poor communication is still the foremost issue in causing delays, cost overrun and extended project durations.

In the generalised view of these studies, the lack of knowledge, qualification and experience of the individuals is a cause of poor communication. Those studies highlights that poor communication is the leading reason for insufficient planning and scheduling and slow in

decision making and variations in design or change order even if the technologies such as BIM are used for construction projects.

This research establishes the challenges associated with KC within a CSC. The development of the framework (figure 2) in this study fills the gap in existing literature while contributing to the KC frameworks especially for, transferring and sharing Tacit Knowledge. Also, the study has the potential to direct further research into effective communication in construction and other industries.

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